Integrated Soil Health Management for Plant Health in Organic Production

Organic Agriculture Workshop

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Background

Health soil can provide multiple ecosystem services

- Food and fiber production
- Water quality and supply
- Pest and disease suppression
- Atmospheric composition and climate regulation
- Biodiversity conservation

Soil health measurements

- SH measurements often lacks soilborne pathogen analysis…can be misleading
- SH management practices can reduce the incidence of soilborne diseases, but the effects vary
- Many plant pathogens are plant-specific. A crop or agroecosystem specific soil health management strategy must be developed

Integrate Soil Health Management (ISHM)

- Applies the concepts of Integrated Pest Management (IPM) and Agroecological transdisciplinary participatory approaches to soilborne disease and soil health management in organic systems
- Offers a framework for developing and implementing a comprehensive site-specific biointensive soil health and soilborne disease management strategy
- Case study: History of soilborne disease management in California strawberries
  - Contrasted with the evolution of arthropod pest management

Case study: History of soilborne disease management in California strawberry

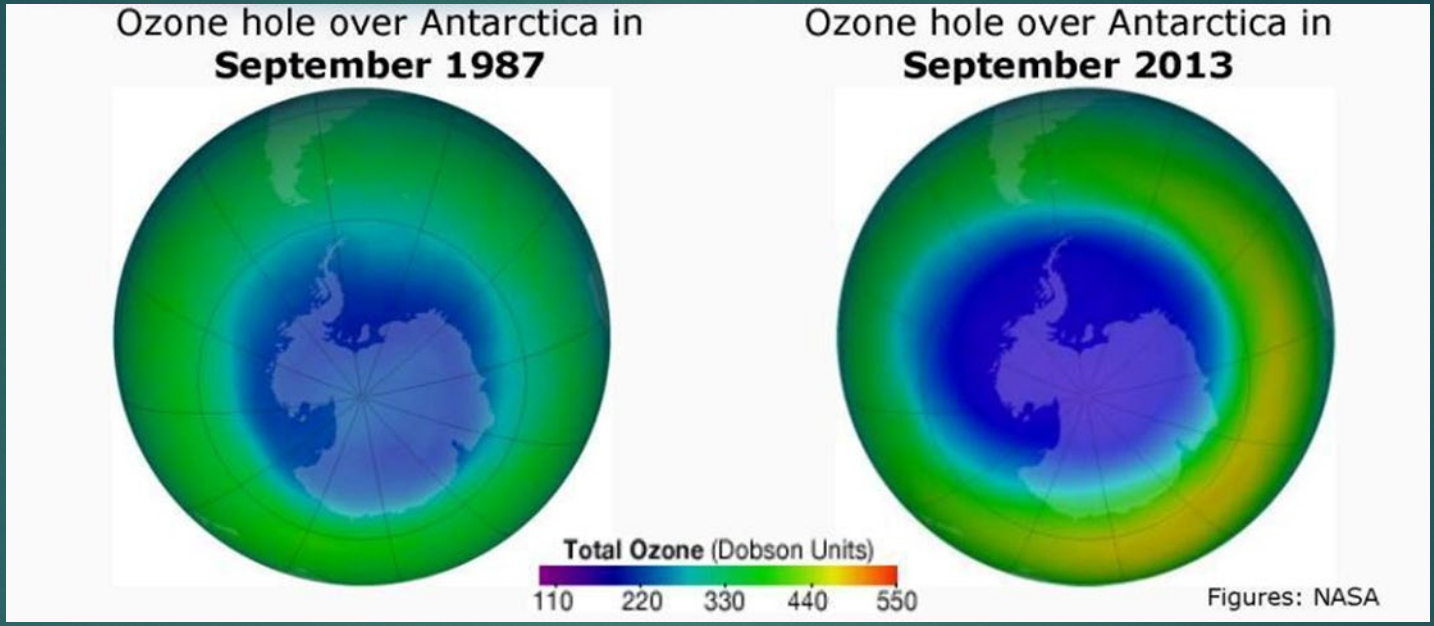
Outbreak of charcoal rot in an organic strawberry field in California

Chemical fumigation (1960 -)

- Methyl bromide + chloropicrin
- Control soilborne disease and weeds, increase yield
- Core technology of $2 billion industry* supporting the large-scale high yielding mono-cultural strawberry production

* 2019 value in California

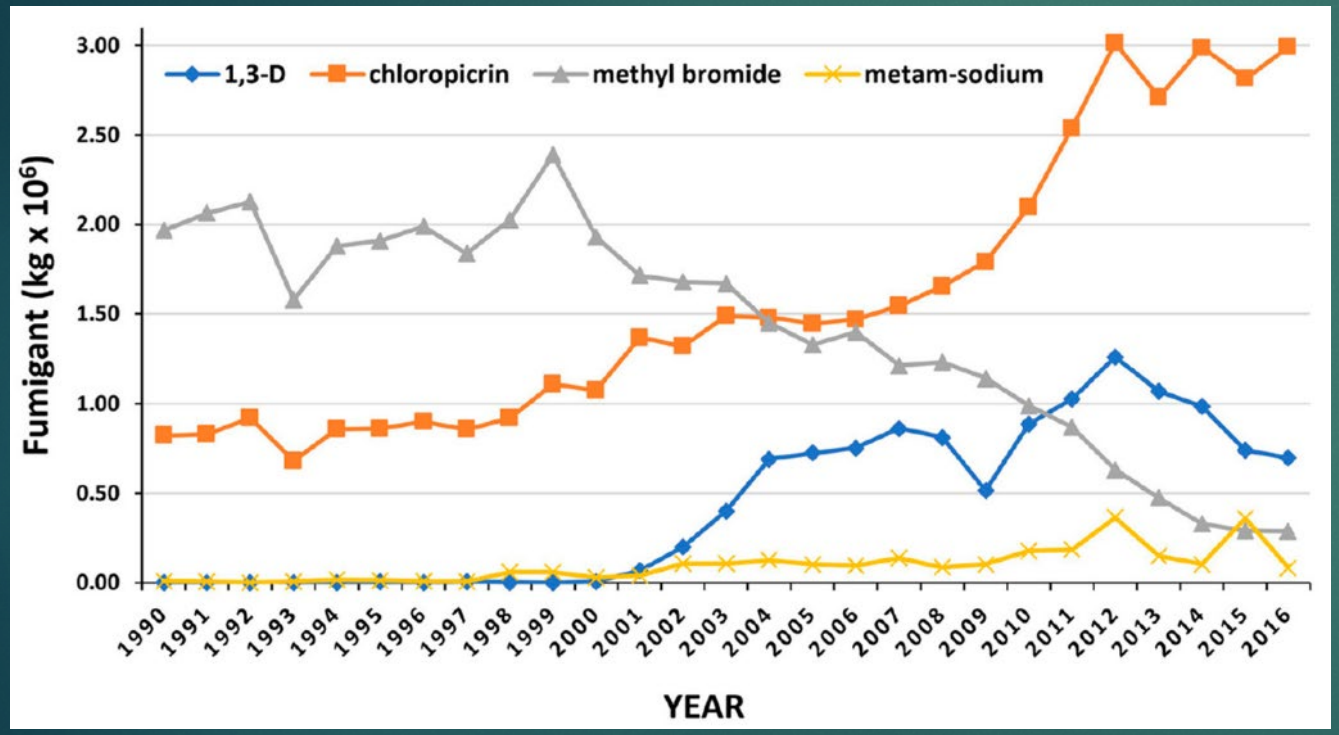
Phasing out methyl bromide (1992 – 2016)



- Ozone layer: Earth's "sun screen" – protects people, plants, and animals from ultraviolet radiation. Skin cancer is the most common cancer in the US
- 1992: Methyl Bromide added to Montreal Protocol
- 2005: 100% phase out with limited exemptions in developed countries
- 2016: Critical Use Exemption in CA expired

Alternative fumigants (2000 -)

Four major soil fumigants used at strawberry fields in California



(Holmes et al., 2020. Phytopathology)

- Since 2003, the California Dept. Pesticide Regulation has documented **hundreds of acute illnesses** caused by accidental fumigant exposure to agricultural workers as well as people living near fumigated fields

-> **Regulation of fumigants is increasingly stringent**

Non-fumigant alternatives (2008-)

- "Farming without Fumigant" Initiative by the California Strawberry Commission (2008-)
  - Substrate production
  - Crop rotation with suppressive crops
  - Anaerobic soil disinfestation (ASD)
  - Soilborne disease resistant varieties
  - Mobile steam machine
  - Integration of above

A standard ASD sequence for California strawberries

Organic Strawberry Acreage In California 1997-2021

Organic/Conventional Comparative On-Farm Strawberry Experiment at the Swanton Berry Farm 1987-1990 (Gliessman et al., 1996)

Data source: 1997-1999: CDFA, 2000-2021: California Strawberry Commission

Molecular methods for soilborne pathogen detections and IPM approach (2012-)

Published year of the molecular approach

Molecular approach	***Verticillium dahliae***	***Fusarium oxysporum* f. sp. *fragariae***	***Macrophomina phaseolina***
Plant test	Dan et al., 2001	Burkhardt et al., 2019	Burkhardt et al., 2018
Soil test	Bilodeau et al., 2012	In development	Burkhardt et al., 2018

- Rapid and accurate quantification
- Allow "scouting" of soilborne pathogens and emerging of the diagnostic-based IPM approach

Evolution of Arthropod Pest Management

- 1950s-80s; Chemical Revolution in Agriculture

  "The only good bug is a dead bug"

- 1970s-; Integrated Pest Management (IPM)

  "Good bugs (beneficials) as well as bad bugs (pests)exist"

  First scouting, then treatment

NATIONAL GEOGRAPHIC

Aug. 6, 2017

Honeybees are crucial for growing crops like almonds and watermelons.

PHOTOGRAPH BY ANAND VARMA, NAT GEO IMAGE COLLECTION

BOOK TALK

Without Bugs, We Might All Be Dead

There are 1.4 billion insects per person on this planet and we need (almost) every one of them.

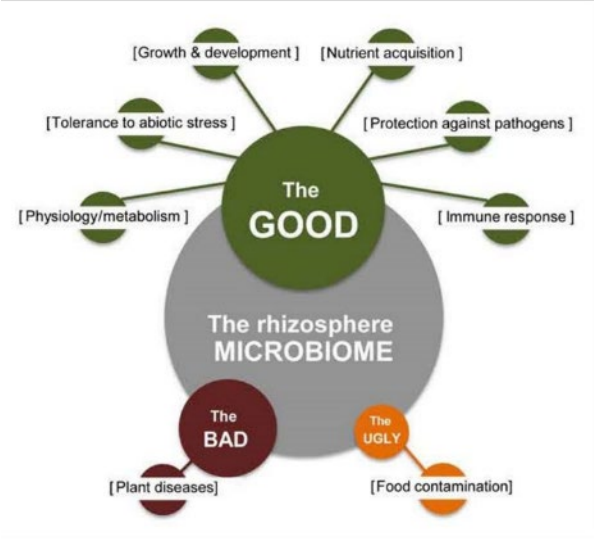
7 MINUTE READ

BY SIMON WORRALL

Challenges of soilborne disease management

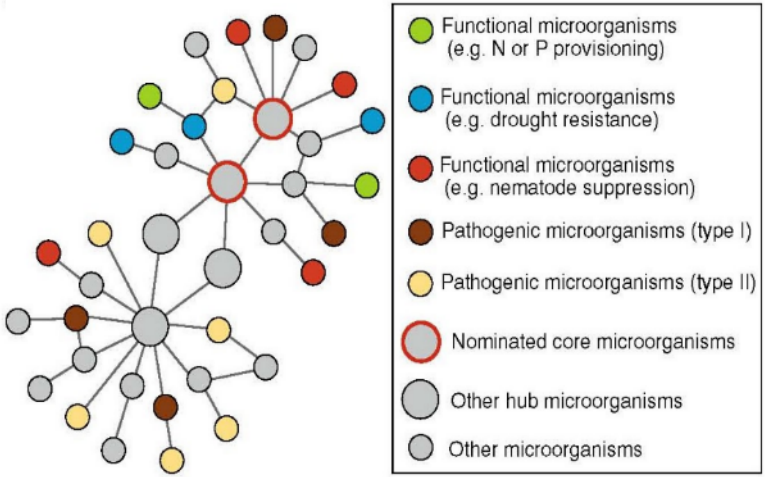
- Invisibility of pathogens
- Lack of post-symptomatic treatments (pre-planting treatment only)
- Limited availability of non-fumigant approaches
- Complexity and diversity of soil ecosystems
- Discovering beneficial and commensal microbes in the soil…Exciting time!

The Good, The Bad, and The Ugly



(Mendes et al., 2013, FEMS Microbiology review)

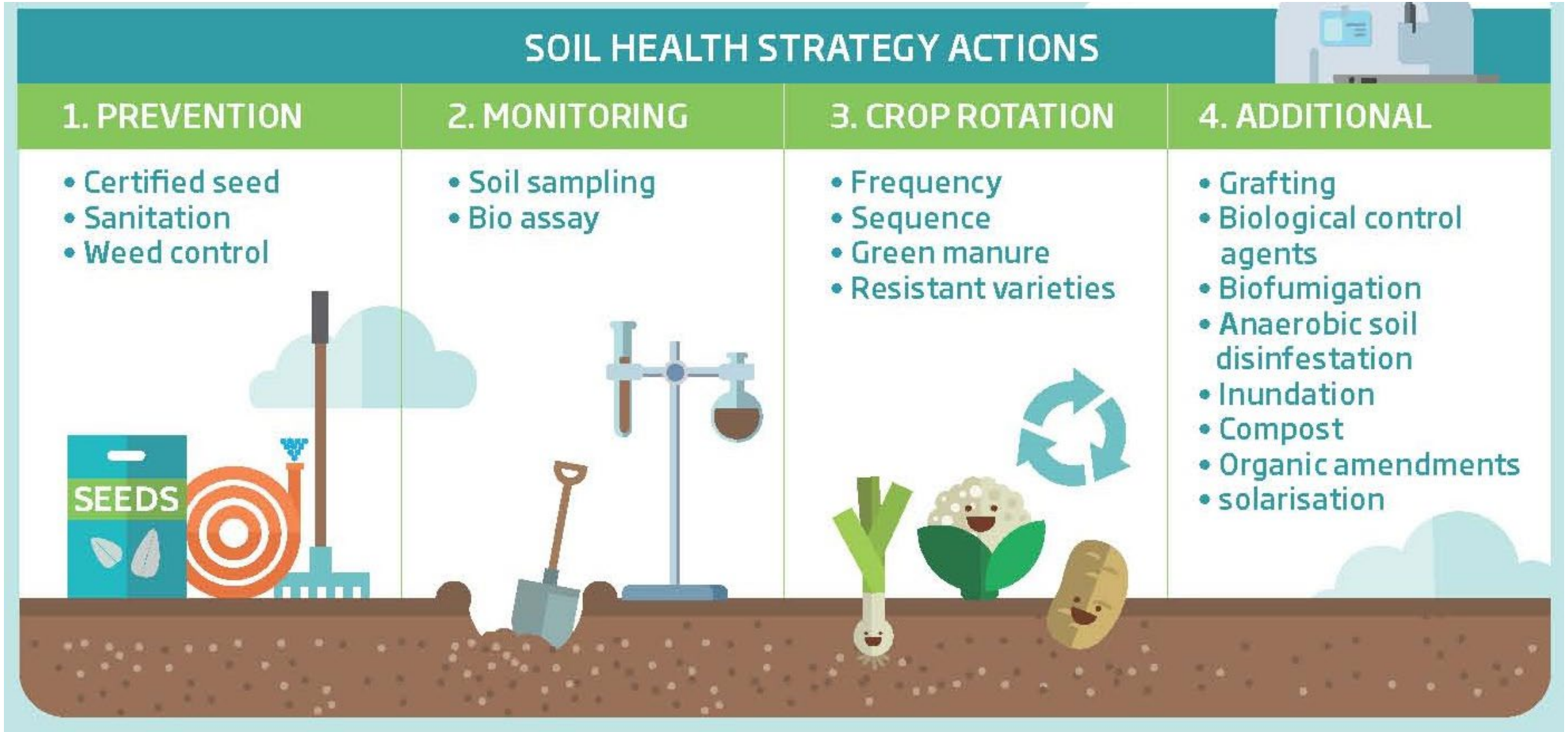
Core Microbiomes



(Toju et al., 2018. Nature Plants)

- Suppressive soil and soil memory
- Plant immunity and rhizosphere immunity
- Improved crops' nutrient uptake by mutualistic fungi

- As we better understand the soil biome's structures and functions, and their relationships with plant health, **indicators of beneficial soil microbes and soil microbial communities for a specific crop or an agroecosystem may be developed**



(EIP-AGRI Focus Group on Soil-borne Diseases. 2015)

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Molecular Diagnostics (PREDICTA)

The SARDI Molecular Diagnostics Centre (MDC) has unique expertise and infrastructure to develop and deliver quantitative DNA based tests for a broad range of soil, stubble and air-borne organisms of economic importance to agriculture.

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- Broadacre and potato growers can access PREDICTA® through a SARDI-accredited agronomist. Contact Nigel Percy on (08) 8429 2236 or email nigel.percy@sa.gov.au for accredited consultants near you.
- Researchers can contact Russell Burns on 0401 122 115 or russell.burns@sa.gov.au with your requirements, and to establish a contract.
- If you have previously accessed our services, please contact us before submitting samples so we can ensure your soil testing bags are correct.
- Contact list of agronomists accredited to deliver PREDICTA® Pt

https://pir.sa.gov.au/research/services/molecular_diagnostics

Integrate Soil Health Management (ISHM)

- science and practice, with social movement advocacy for non-toxic agriculture
- ISHM may evolve similarly to IPM for arthropod pest management;
  - toward biointensive management,
  - increasing prioritization of the role of beneficial organisms, and
  - redesigning cropping systems and cultural practices that prevent soil-borne diseases and induce sustained soil and plant health

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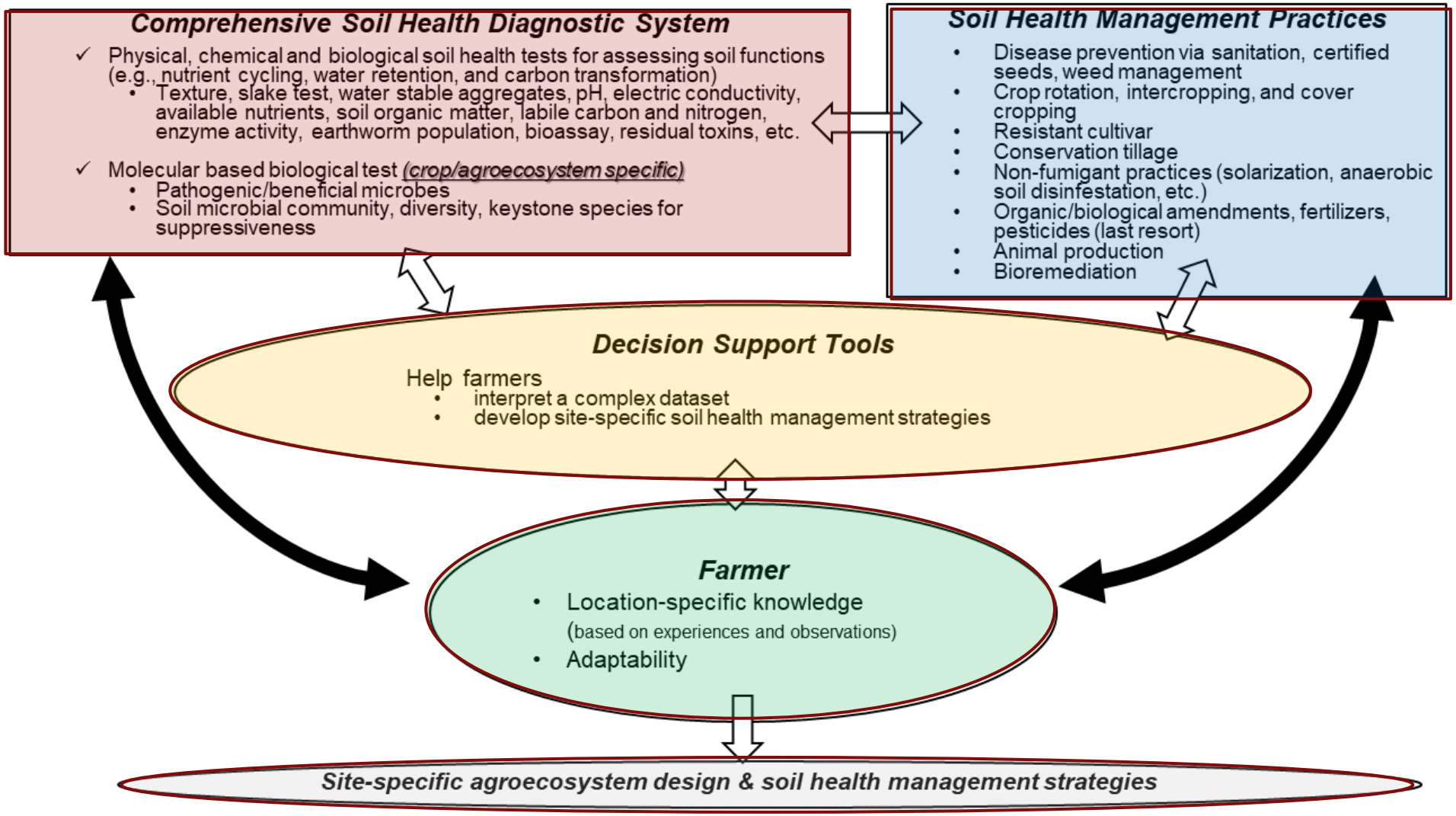

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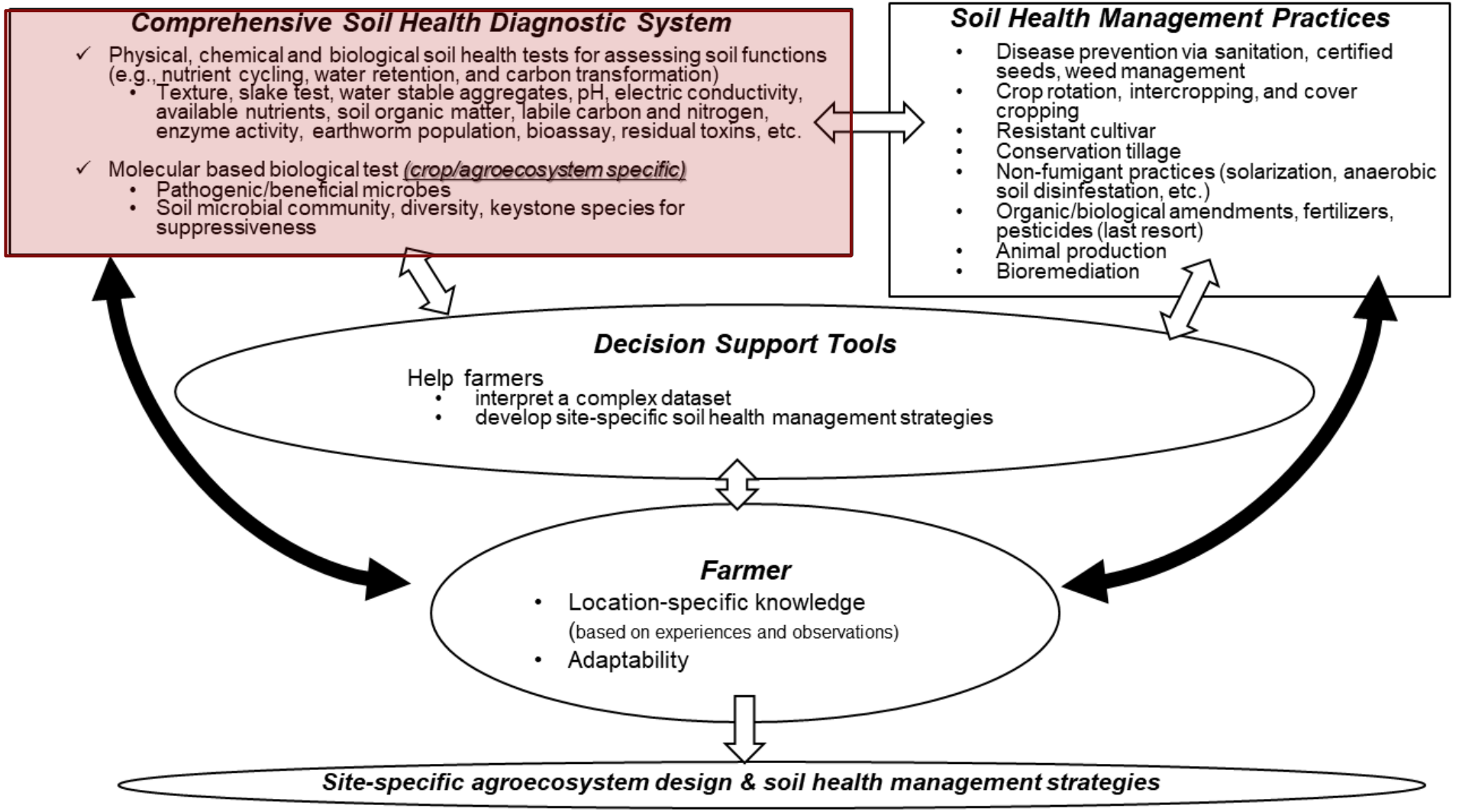

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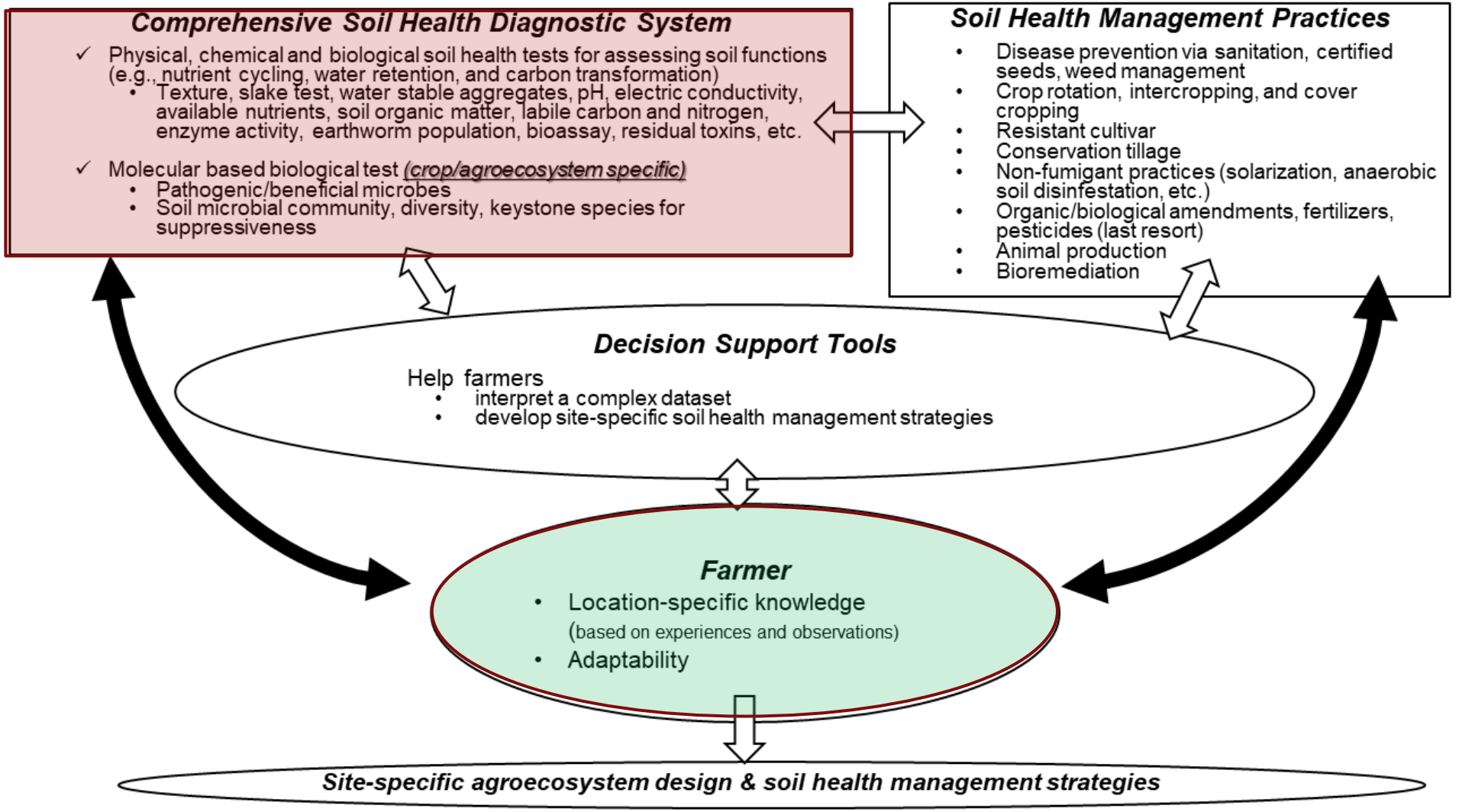

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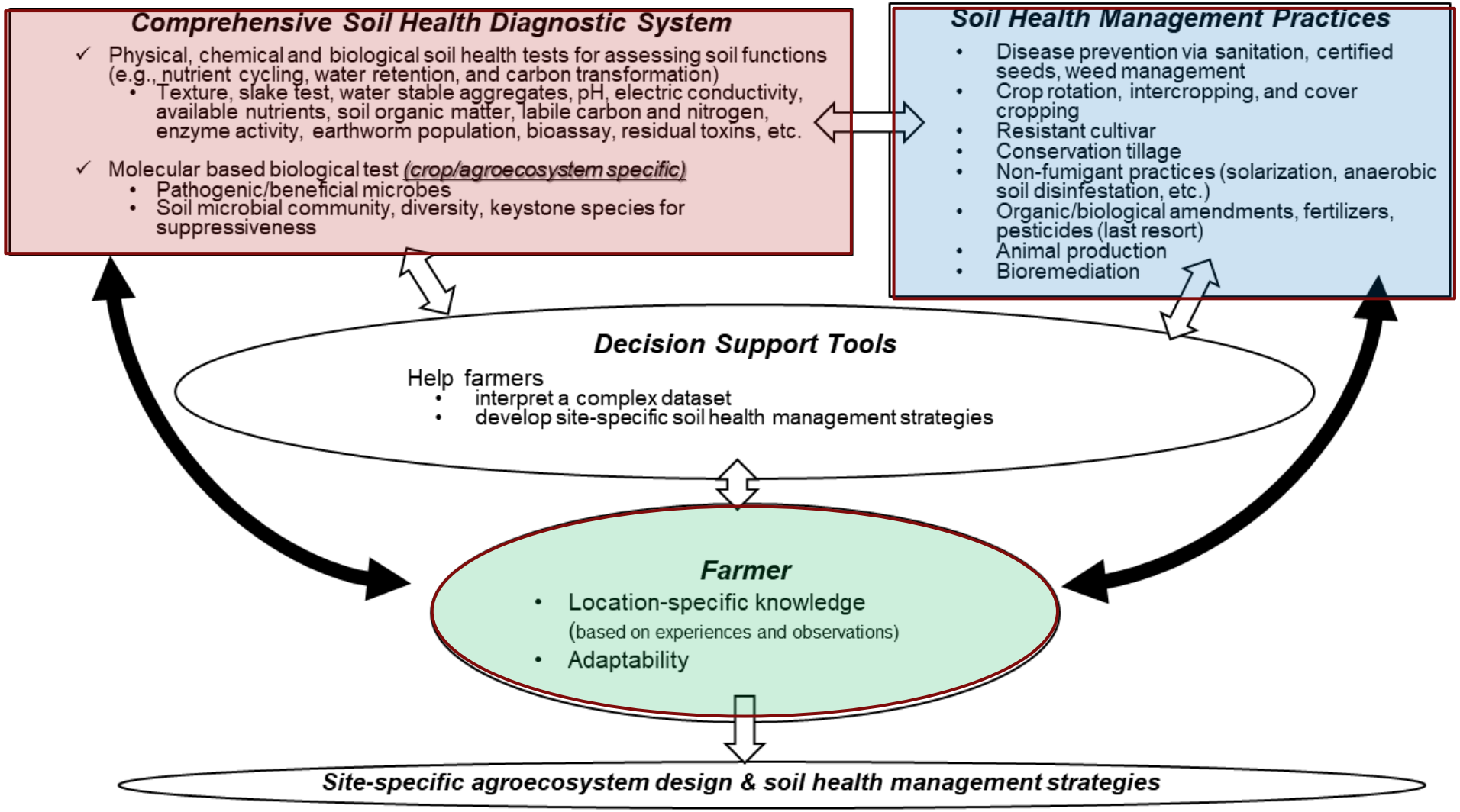

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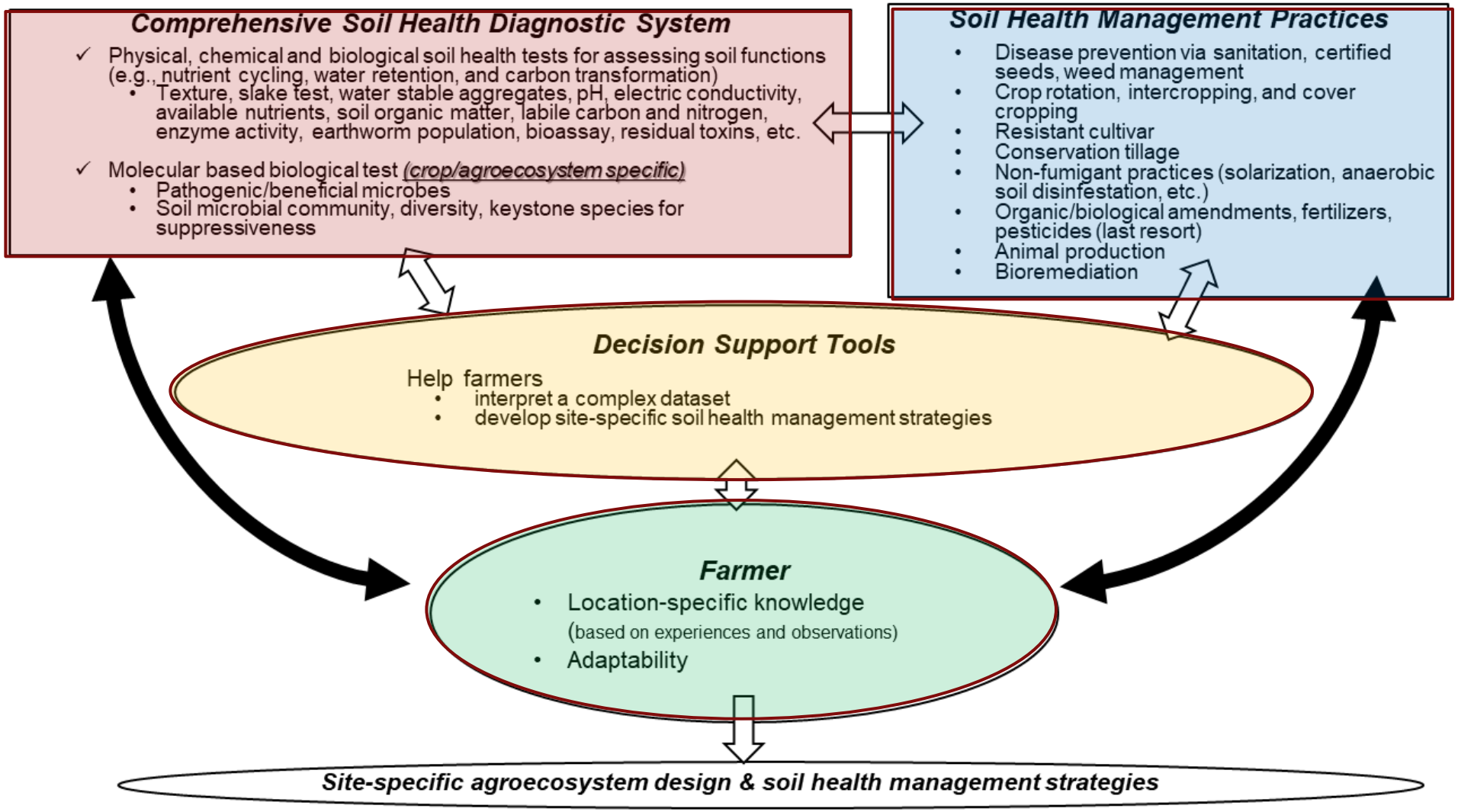

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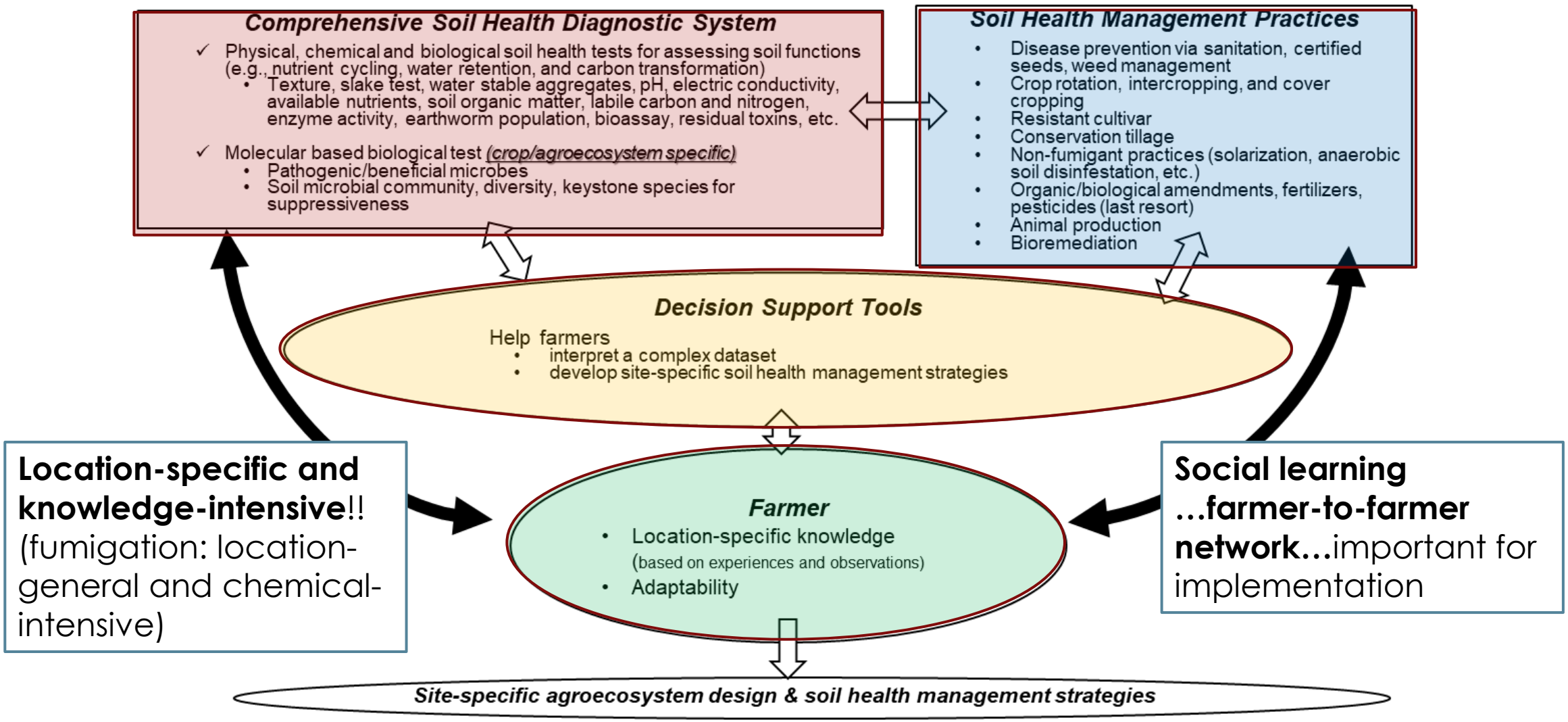

Levels of Conversion: From Industrial Agriculture to a Sustainable World Food System (Gliessman, 2015)

Level	Scale	ree Aspects	
		:tice and :ation	Social Change
1. Increase efficiency of industrial practices	Farm	ınd lessens ıl impacts	**Minor**
		to :actices	**Minor**
2. Substitute alternative practices and inputs	Farm	stainability :ale	**Important** Builds enterprise viability and societal support
		nd lationships	**Primary** Economies restructured; values and behaviors changed
3. Redesign whole agroecosystems	Farm, region	:tical basis igm shift	**Primary** World systems fundamentally transformed

Park Farming Organics; Scott, Brian, and Ulla Park

- 35 yrs. emphasis on soil health
- 560 ha, 23 fields, 10-15 crops
- All certified regenerative organic
- System of "9Cs"
  1. Cover crops
  2. Crop rotation
  3. Conservation tillage
  4. Crop residue
  5. Conserve inputs
  6. Controlled traffic
  7. Compost
  8. Critter cover
  9. Crew care

Soil Health Affects Pest Damage on Tomatoes

nature plants

ARTICLES

https://doi.org/10.1038/s41477-020-0656-9

Check for updates

Organic management promotes natural pest control through altered plant resistance to insects

Robert Blundell[1], Jennifer E. Schmidt[2], Alexandria Igwe[3], Andrea L. Cheung[1], Rachel L. Vannette[3], Amélie C. M. Gaudin and Clare L. Casteel[1,4]

- Less leafhopper damages on tomatoes in an organic farm compared to adjacent conventional farms has been observed
- Changes in leafhopper settling between organically and conventionally grown tomatoes are dependent on the increased plant resistance by the salicylic acid accumulation in plants mediated by rhizosphere microbial communities
- Soil health improves plant resistance to arthropod pests

Future research needs in ISHM

- Utilizing mechanistic models in plants-soil microbe functions such as soil suppressiveness, plant immunity, nutrient uptake
- Better chemical and biological characterization of organic amendments and crop residues, and their relationships with soilborne disease suppressiveness
- Increased efficacy of plant growth-promoting microbes in soil-borne disease suppression and nutrient uptake in field conditions
- Development of crop cultivars with ability to modify their rhizosphere microbiome for their benefits
- Facilitating social-learning among growers and transdisciplinary collaboration of researchers, growers, farmworkers, NGOs, industry, and policymakers

frontiers in Sustainable Food Systems

PERSPECTIVE
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Integrated Soil Health Management for Plant Health and One Health: Lessons From Histories of Soil-borne Disease Management in California Strawberries and Arthropod Pest Management

OPEN ACCESS

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Integrated Soil Health Management for Plant Health and One Health

Muramoto, Parr, Perez, and Wong (2022)

https://www.scipod.global/dr-joji-muramoto-healthy-soils-healthy-planet-healthy-humans/


Question?
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